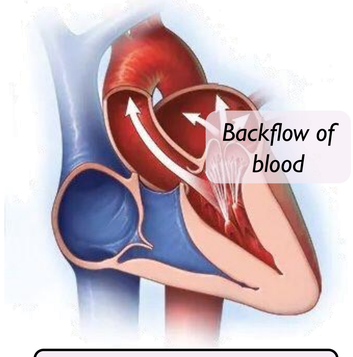
Minimally Invasive Annuloplasty Using Shape-Memory Materials

Jordan Low Jun Yi[1], Chen Yanlin[1], Kuo Hsin Wei[1], Chiam Sher-Yi[1], Faizus Sazzad[2]
[1]NUS High School of Mathematics and Science, [2]NUS Yong Loo Lin School of Medicine (MD6)

1. Introduction



Mitral Valve Regurgitation

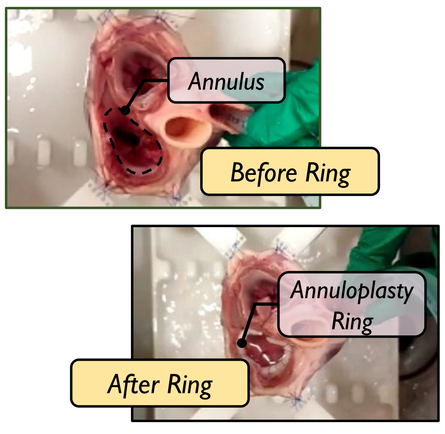
Issue at hand

- Backflow of blood results in severe complications that necessitate an annuloplasty
- Conventional procedure includes a median sternotomy which requires a 25-30cm skin incision and splitting of the sternum
- Surgical trauma can lead to complications and long recovery periods

Proposed solution

Thermosensitive shape memory materials

- ✓ Unique property: returns to its original trained shape upon heating, even after being deformed
- ✓ Ring can be inserted as a thin rod, which reverts to its original ring shape in the heart
  - Shape memory alloys – Nitinol: biocompatible
  - Shape memory polymers – (MMA-PEGDMA) copolymer: biocompatible *and* biodegradable



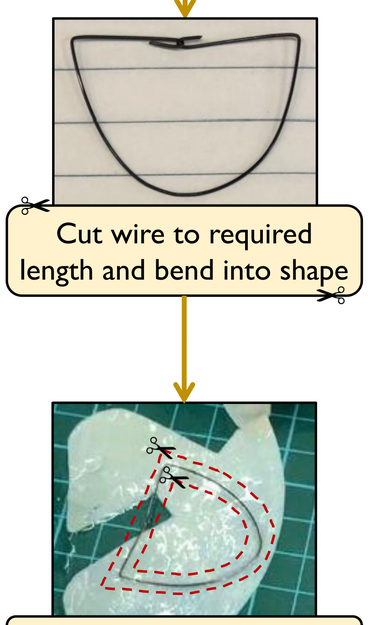
2. Methodology

2.1 Making the Annuloplasty Rings

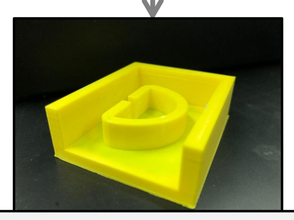
Use sizer to measure size of the annulus → Construct the annulus ring using the dimensions measured → Flatten ring and place in 35°C water → Suture ring onto annulus after shape recovery

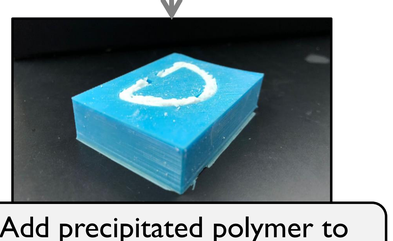
Construct the annulus ring using the dimensions measured → Nitinol / MMA-PEGDMA

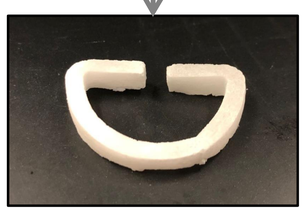
Nitinol: Cut wire to required length and bend into shape → Wrap wire in myocardium



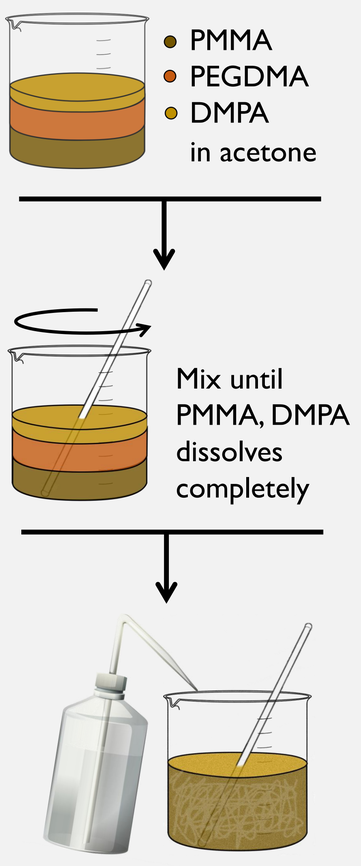
MMA-PEGDMA: Add silicon rubber mix to 3D printed negative mold → Add precipitated polymer to silicon mold and place under UV





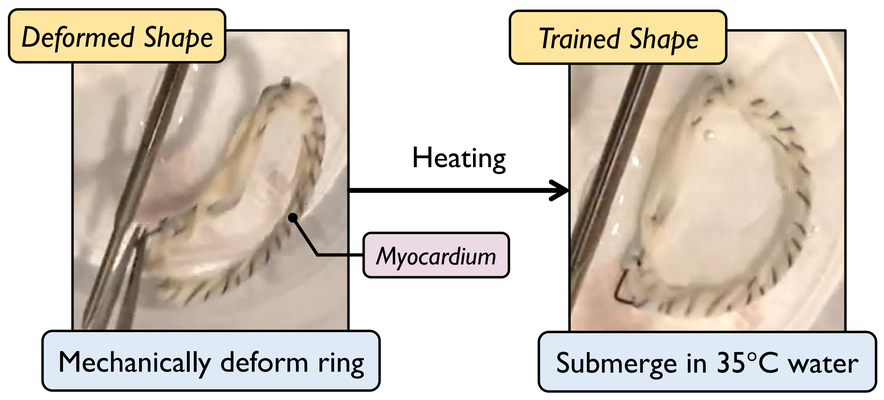


Preparing MMA-PEGDMA



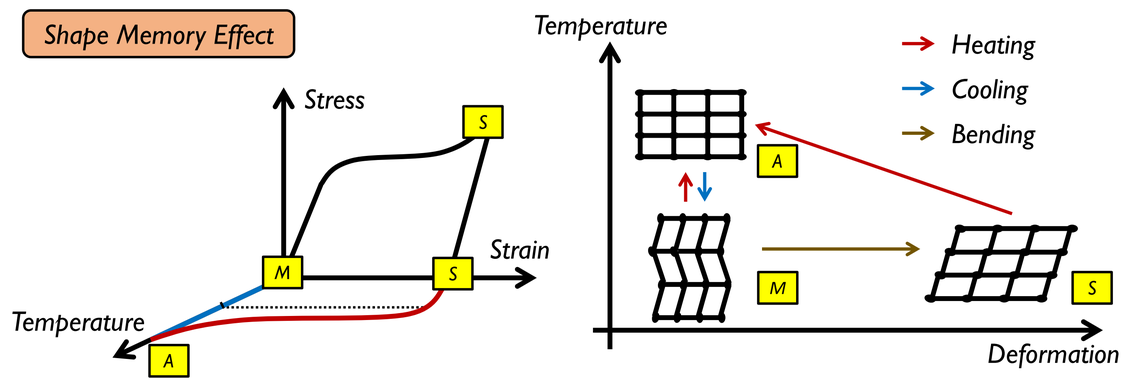
2.2 Testing the Annuloplasty Rings

Flatten ring and place in 35°C water → Suture ring onto annulus after shape recovery



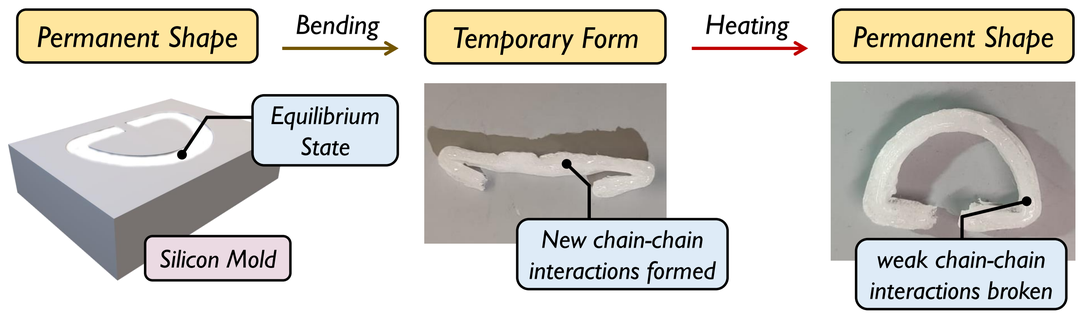
3. Results and Discussion

3.1 Shape Memory Effect of Nitinol Alloy

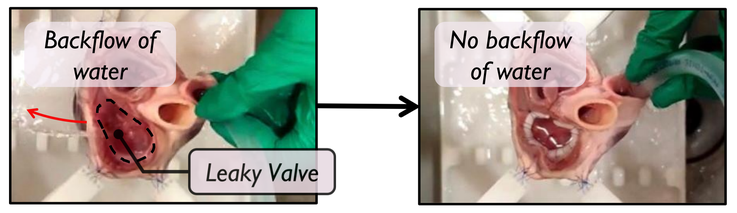


Wire Thickness	Initial Shape	Final Shape	Observations
0.20 mm			Wire reverts instantly when heated: insufficient time to insert into heart
0.50 mm			***Optimal thickness***; able to revert in 35°C water
1.00 mm			Does not visibly revert in 35°C water; only reverts in 70°C water

3.2 Shape Memory Effect of MMA-PEGDMA Copolymer



3.3 Reducing Mitral Valve Regurgitation



✓ *Regurgitation is reduced*

4. Conclusion

- We successfully created **thermosensitive** annulus rings using MMA-PEGDMA copolymer, a biocompatible and biodegradable shape memory polymer
- Shape memory effect allows for minimally invasive surgical procedures; Biodegradability allows the procedure to be carried out in growing children

5. References

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